# Appendix K

# Subsurface Exploration and Geotechnical Engineering Report

## Preliminary

SUBSURFACE EXPLORATION
AND
GEOTECHNICAL ENGINEERING REPORT
(PRELIMINARY)

PERMANENT (RCI) ELEMENTARY SCHOOL
L.I. 62291, FY-06
Fort Stewart, Georgia

By
Soils Section
Geotechnical & HTRW Branch
U.S. Army Engineer District, Savannah

MAY 2005

# TABLE OF CONTENTS

SUBSURFACE EXPLORATION AND
GEOTECHNICAL ENGINEERING REPORT
(PRELIMINARY)

PERMANENT (RCI) ELEMENTARY SCHOOL
L.I. 62291, FY-06
Fort Stewart, Georgia

1. **PURPOSE**. The Government has conducted a preliminary geotechnical investigation for the proposed project. This report provides an overview of the site conditions, including subsurface soil and ground-water conditions, and preliminary recommendations pertaining to the geotechnical design and construction of the project.

2. **QUALIFICATIONS OF REPORT**. The field explorations performed for this report were made to determine the subsurface soil and ground-water conditions and were not intended to serve as an assessment of site environmental conditions. No effort was made to define, delineate, or designate any areas of environmental concern or of contamination. Any recommendations regarding drainage and earthwork construction are made on the basis that such work can be performed in accordance with applicable laws pertaining to environmental contamination.

3. **PROJECT DESCRIPTION**. The Fort Stewart FY06 Permanent Elementary School will be one-story building. The school will be approximately 80,800 square feet. The Permanent Elementary School project will also include parking areas, bus drop-off areas, pedestrian walkways, and an emergency vehicle access road.

Since the project will be constructed under a design/build contract, detailed structural information for the proposed building is unavailable. However, some of the pertinent design features are described below. The exterior wall is anticipated to be reinforced concrete masonry units (CMU) with brick veneer. The buildings will likely be supported by spread foundations and/or continuous footings. Slab-on-grade construction, which will likely consist of a 4 inch thick, cast-in-place concrete slab on grade on a vapor barrier over a 4-inch capillary water barrier, is proposed in this RFP.

**4. EXPLORATION PROCEDURES**.

**a. Site Reconnaissance**. Prior to the field exploration, the site and surrounding areas were visually inspected by a geotechnical engineer. The observations were used in planning the exploration, in determining areas of special interest, and in relating site conditions to known geologic conditions in the area.

**b. Field Exploration.**

(1) Subsurface conditions at the Permanent Elementary School site were explored by total of twelve soil penetration test (SPT) borings, designated B-01 through B-12. The locations of SPT borings are shown on the drawings included with this RFP. Depth SPT borings ranged from 5 feet to 25 feet.

(2) Boring locations were established in the field by an engineer by measuring distances and estimating right angles from existing roads and other features. The ground surface elevation at each soil boring location was determined by interpolation from the site topography survey. Since the measurements were not precise, the locations shown on the boring location plan and the elevations on the boring logs should be considered approximate.

(3) The soil test borings were drilled by Savannah District using a CME 550 drill rig. A 4-inch spiral auger and standard split spoon sampler were used to advance the boreholes. Soil sampling and Standard Penetration Testing (SPT) were in accordance with ASTM D 1586. In the Standard Penetration Test, a soil sample is obtained with a standard 1⅜ inch I.D. by 2 inches O.D. split-barrel sampler. The sampler is seated in the first 6 inches and then driven an additional 12 inches with blows from a 140 lb. hammer falling a distance of 30 inches. The number of blows required to drive the sampler the final 12 inches is recorded and is termed the "standard penetration resistance" or the "N-value". Penetration resistance, when properly evaluated, is an index of the soil's strength, density, and foundation support capability. Ground-water levels were measured in the boreholes at the completion of drilling and, in some cases, at some time following completion of the borings, as time permitted.

(5) Representative portions of the soil samples obtained from the soil test borings were examined and field classified by a geologist. Samples were also visually inspected by a geotechnical engineer at the Savannah district Office. Classification of the soil samples was performed in general accordance with ASTM D 2488 (Visual-Manual Procedure for Description of Soils). Soils were classified in accordance with the Unified Soil Classification System described in ASTM D 2487 (Classification of Soils for Engineering Purposes). Since the soil descriptions and classifications are based on visual examination, they should be considered approximate.

(6) Logs of soil test borings graphically depicting soil descriptions, standard penetration resistances, and observed ground-water levels are shown on the drawings with this RFP.

## 5. SITE AND SUBSURFACE CONDITIONS.

### a. Site Description

The proposed FY06 permanent elementary school site is bounded by Austin Road on the east, Liberty Drive on the south and Liberty Woods Housing Facility (which is currently under construction) on the north.

The site is relatively flat, with a gentle slope from approximately elevation 79 on the north perimeter to a lowest elevation of 68 along a segment at the top of the southern boundary ditch. The existing site is undeveloped and is presently heavily wooded, including thick brush at the surface.

### b. Area and Site Geology.

Fort Stewart is located near the eastern edge of the South Atlantic Coastal Plain. In South Carolina and Georgia, this broad, gently sloping region extends southeastward from the Fall Line

(Columbia-Augusta-Macon-Columbus) to the Atlantic Ocean. The soils encountered are predominantly sedimentary in origin and consist of layered marine deposits of sands, silts and clays. The deposits have since been subjected to successive erosion and re-deposition by fluctuations of sea levels, storm tides and winds. Many of the surface sands are the result of depositional forces along ancient beaches which formed during the changing shoreline and river conditions. Intermittent deposits of shells occur within the strata at irregular intervals.

**c. Subsurface Conditions**.

(1) Natural soils were encountered in all of the soil test borings. The soil boring logs show that the soil profile at the project site generally consists of Silty Sand (SM). The SPT or "N" values in the shallow five feet borings ranged from 2 to 22 indicating very loose to medium relative density. The SPT or "N" values in the deeper 15 and 25 feet soil borings ranged from 2 to 40 in the top 6 feet, indicating very loose to dense relative density. Below six feet, the "N" values are generally 50 or higher, indicating very dense relative density. This very dense material is locally termed "hard pan". The "hard pan" layer is estimated to be 5 to 10 feet thick based on "N" values and soil description. The silty sands beneath the "hard pan" are generally medium stiff to very stiff.

(3) The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The SPT boring logs shown on the drawings should be reviewed for specific information at individual locations. The stratifications shown on the SPT boring logs represent the conditions at the boring locations. Variations may occur and should be expected between boring locations. The stratifications represent the approximate boundary between the subsurface materials; the actual transition may be gradual.

**d. Ground-Water Conditions**.

Water levels were measured in all SPT soil test borings during drilling. Water levels were also measured in few SPT borings after 24 hours as time permitted. The soil test borings were immediately backfilled after water level readings were noted.

SPT borings B-1 through B-8 indicates that in general, the ground-water level readings ranged from 2.5 feet to 18.5 feet below the existing grade. No ground water was detected in SPT borings B-9 through B-12. A 24 hour water level reading was taken only in SPT boring B-3 and was found to be 7.8 feet below the existing ground. The borings show a large variance in water level between readings measured during drilling, after the completion of drilling, and after 24 hours. The long term stabilized water level readings are considered more accurate than the readings taken during or immediately after drilling. It is our opinion that in general the ground-water level for the project site will vary between 3 to 9 feet below the existing ground depending on weather conditions and time of the year.

Ground-water depths shown on the boring logs represent ground water encountered on the dates shown. Ground-water levels will fluctuate with seasonal and climatic variations, variations in subsurface soil conditions, and construction operations. Therefore, ground-water conditions in the future, and at other locations on the site, may differ from the conditions encountered at the boring locations on the dates the borings were performed.

## 6. ENGINEERING EVALUATIONS AND RECOMMENDATIONS.

**a. General**. The following recommendations are based on the information available on the proposed structures, observations made at the project site, interpretation of the data obtained from the subsurface investigations, and our experience at Ft. Stewart with soils and subsurface conditions similar to those encountered at the site. Since the soil test borings represent a very small statistical sampling of the subsurface conditions, subsurface conditions could vary substantially from those indicated by the soil test borings. In such instances, adjustments to the design and construction of the proposed structures might be necessary, depending on the conditions encountered.

**b. General Site Preparation**. Following the clearing and removal of trees, the construction areas should be grubbed and stripped of all vegetation, topsoil, organics, and other deleterious materials. Clean topsoil can be stockpiled and reused in landscaped areas. Any existing utilities in construction areas should be located and rerouted, as necessary.

**c. Foundation Design and Construction**.

(1) Given the proposed sites and the proposed types of structures, it is our opinion that shallow spread foundations can be used for support of the proposed buildings.

(2) Footings should be supported on properly compacted in-situ soils or structural fill. Column footings and load bearing wall footings should have minimum dimensions of 30 and 24 inches, respectively, and should be located at a minimum depth of 24 inches below finish floor or finish grade, whichever is lower. Non-load bearing wall footings should have a minimum width of 18 inches and should be located at a depth of 18 inches below finish floor or finish grade, whichever is lower.

(3) Foundation excavations should be concreted as soon as practical following excavation. Exposure to the environment could weaken the soils at the footing bearing level should the foundation excavations remain open for an extended period of time. Bottoms of foundation excavations should be inspected immediately prior to placement of reinforcing steel and concrete to verify that adequate bearing soils are present and that all debris, mud, and loose, frozen or water softened soils have been removed. If the bearing surface soils have been softened by surface-water intrusion or by exposure, the softened soils must be removed to firm bearing and replaced with additional concrete during the concreting or replaced to design subgrade with No. 57 or No. 67 stone, compacted to a non-yielding condition. To minimize the exposure, the final excavation (4 to 6 inches) to design subgrade could be delayed until just prior to placement of reinforcing steel and concreting. Foundation excavations must be maintained in a drained/dewatered condition throughout the construction process. Loose surficial cohesionless soils were encountered in SPT borings B-1, B-3 and B-8. These soils should be removed and recompacted to 92% of dry density.

**d. Seismic Design.** Seismic loads should be computed in accordance with IBC 2000, except as modified by UFC 1-200-01. The project site is classified as Site Class D for the purpose of determining maximum considered earthquake spectral response accelerations.

**e. Concrete Slabs-On-Grade.**

(1) Based upon our past experience and the subsurface conditions encountered at the site, concrete floor slabs can be supported on in-situ soils or on fill soils placed and compacted in accordance with the specification section EARTHWORK. We recommend that all concrete slabs-on-grade be underlain by a minimum of 4 inches of open graded, washed pea gravel, or stone, often termed “capillary water barrier,” to prevent the capillary rise of ground water. Gradation Nos. 57, 67, 78, or 89 stone are suitable for this purpose. All drawings should be consistently labeled with the term “capillary water barrier” since this is the term utilized in specification Section EARTHWORK. We also recommend that a moisture vapor barrier consisting of lapped polyethylene sheeting having a minimum thickness of 6 mils be provided beneath the building floor slabs to reduce the potential for slab dampness from soil moisture. Concrete slabs should be jointed around columns and along supported walls to minimize cracking due to possible differential movement.

(2) Construction activities and exposure to the environment often cause deterioration of the prepared slab-on-grade subgrade. Therefore, we recommend that the slab subgrade soil be inspected and evaluated immediately prior to floor slab construction. The evaluation might include a combination of visual observations, hand rod probing, and field density tests to verify that the subgrade has been properly prepared. If unstable soil is revealed, the affected soil should be removed to firm bearing and replaced to design subgrade with suitable structural fill soil placed and compacted as recommended or replaced with additional capillary water barrier material.

**f. Ground Water Considerations.**

(1) Groundwater will be encountered during construction. The AE/Contractor will be responsible for controlling all water, both ground and surface, such that all excavations, foundation and utility construction, and filling/backfilling are performed in the dry.

(2) Ground-water and “Perched ground-water” conditions could be encountered, and the accumulation of run-off water or seepage at the base of excavations may occur during foundation construction and site work. Where seepage is encountered at shallow depths, pumping from filtered sumps and/or the use of perimeter trenches to collect and discharge the water away from the work area should be utilized. A well-point dewatering system may be required if other means do not maintain groundwater at least two feet below the working level.

(3) Water should not be allowed to collect near the foundation or on floor slab areas of the building either during or after construction. Undercut or excavated areas should be sloped toward one corner to facilitate removal of any collected rain water, ground water, or surface runoff. Positive site drainage should be provided to reduce infiltration of surface water around the perimeter of the building and beneath the floor slabs.

**g. Structural Fill**. In order to achieve high density structural fill, the following evaluations and recommendations are offered:

(1) Based on the soil test borings, excavated on-site soils (excluding any organics and debris) can be used as structural fill. Some moisture content adjustment will probably be necessary

to achieve proper compaction. If water must be added, it should be uniformly applied and thoroughly mixed into the soil by discing.

(2) We recommend that the contractor have appropriate disc harrows on site during earthwork for both drying and wetting the soils.

(3) Materials selected for use as structural fill should be free from roots and other organic matter, trash, debris, and frozen soil and stones larger than 3 inches in any dimension. The following soils represented by their Unified Soil Classification System (ASTM D 2487) group symbols will be suitable for use as structural fill: GC, GM, SP, SW, SC, SM, ML and CL. The following soil types are considered unsuitable: Pt, OH, OL, GP, GW, MH and CH.

(4) Suitable fill soils should be placed in lifts of a maximum 8 inches loose measurement. The soil should be compacted by mechanical means such as steel drum, sheepsfoot, tamping, or rubber-tired rollers. Compaction of clays is best accomplished with a sheepsfoot or tamping roller. Periodically rolling with heavily loaded, rubber-tired equipment may be desirable to seal the surface of the compacted fill, thus reducing the potential for absorption of surface water following a rain. This sealing operation is particularly important at the end of the workday and at the end of the week. Within confined areas or foundation excavations, we recommend the use of manually operated, internal combustion activated compactors (“wacker packers” or sled tamps). The compactors should have sufficient weight and striking power to produce the same degree of compaction that is obtained on the other portions of the fill by the rolling equipment as specified. Where hand operated equipment is used, the soils should be placed in lifts of maximum 4 inches loose measurement.

(5) We recommend the structural fill and subgrades are compacted to the following minimum percents of the modified Proctor maximum dry density (ASTM D 1557):

| | |
|---|---|
| Beneath structures and building slabs, to 5 feet beyond building and structure line, around footings and in trenches | 92 percent |
| Beneath paved areas, except top 12 inches | 92 percent |
| Beneath paved areas, top 12 inches | 95 percent |
| Beneath sidewalks and grassed areas | 85 percent |

**h. Construction Quality Control Testing**.

(1) Prior to initiating any structural fill placement and/or compaction operations, we recommend that representative samples of the soils which will be used as structural fill or subgrade, both suitable on-site soils and off-site soils (borrow), be obtained and tested to determine their classification and compaction characteristics. The samples should be carefully selected to represent the full range of soil types to be used. The moisture content, maximum dry density, optimum moisture content, grain-size and plasticity characteristics should be determined. These tests are

required to determine if the fill and subgrade soils are acceptable and for compaction quality control of the subgrades and structural fill. Tests for the above soil properties should be in accordance with the following:

| | |
|---|---|
| Moisture Content | ASTM D 2216 |
| Maximum Dry Density and Optimum Moisture | ASTM D 1557 |
| Grain-Size (Wash No. 200, less hydrometer) | ASTM D 422 and D 1140 |
| Plasticity | ASTM D 4318 |

(2) A representative number of in-place field density tests should be performed in the subgrade of compacted on-site soils and in the structural fill and backfill to confirm that the required degree of compaction has been obtained. In-place density tests should be performed in accordance with the sand cone method prescribed in ASTM D 1556. We recommend at least one density test be performed for each 5,000 square feet, or portion thereof, of compacted subgrades, and 7,500 square feet for <u>each</u> lift of compacted structural fill. We also recommend that at least one density test be performed for each 100 linear feet in the bearing level soils of continuous footings. In addition, a density test should be performed for each 150 linear feet of backfill placed per foot of depth in trenches for utilities systems. Where other areas are compacted separately by manually operated compactors, a minimum of one density test should be performed for every 250 square feet, or portion thereof, of fill placed per foot of depth.

(3) Compaction control of soils requires the comparison of fill water content and dry density values obtained in the field density tests with optimum water content and maximum dry density. The performance of a laboratory compaction test on material from each field density test would provide the most accurate relation of the in-place material to optimum water content and maximum density, but it is not feasible to do this as the testing could not keep pace with fill construction. We recommend that compaction control of the earthwork construction be performed using a “family” of compaction curves and the one-point or two-point compaction methods. These methods are described and included in Savannah District guide specification 02300S, EARTHWORK.

(4) Any area that does not meet the required compaction criteria should be reworked and retested. If the moisture content of the soil is within the recommended range, additional compaction may be all that is necessary to increase the density. If the moisture content is not within the recommended range, then the moisture content should be adjusted to within the range and the area recompacted.

(5) All laboratory and field density testing should be performed by an approved commercial testing laboratory qualified in this type of work and approved by the US Army Corps of Engineers, Savannah District.

**i. Specification:** The AE/Contractor shall use Savannah District guide specification 02300S, EARTHWORK, as part of the contract specifications. Note that this guide specification must be obtained from Savannah District as it has been modified from the original CEGS guide.